ECG087

Energy Consumption Guide

# Energy use in Local Authority Buildings

CARBON TRUST

Making business sense of climate change


ISLINGTON TOWN HALL
Islington Town Hall
ISLINGTON

# Contents



***This Guide assists those responsible for building energy consumption within Local Authorities to:***

- *Assess energy performance against benchmark data for a variety of different building types*
- *Calculate an overall portfolio benchmark to enable comparison with other groups of buildings*
- *Identify buildings for priority attention*
- *Assess the true scope for energy reduction and achievement of a defined standard of performance*
- *Achieve reduction in fuel usage and carbon emissions*
- *Reduce impact on the environment*
- *Achieve Government fuel reduction targets.*

# 1 Introduction

### Purpose

This guide has been produced for those involved within Local Authority property management at all levels. It helps to assess energy performance of individual buildings quickly and effectively. It also advises on measuring the performance of the portfolio as a whole.

A tabular assessment helps to identify buildings with the most potential for savings and gives guidance for priority actions.

### Who is the guide for?

This Guide is for professional energy managers within Local Authorities and officers involved in managing property departments. While this guide has been prepared using data from Local Authorities in England and Northern Ireland, it can be successfully applied to establishments throughout the UK. Users should however recognise the need to apply local degree day data and be aware of possible differences in the utilisation of buildings.

### Building types included in this guide

The following building types, based on the data returned by Local Authorities for the compilation of this Guide, are significant energy users within Local Authority portfolios:

- Town Halls
- Civic office buildings
- Leisure centres
- Residential care homes
- Sheltered housing
- Housing units for homeless people
- Museums
- Libraries
- Community centres
- Day centres
- Depots
- Car parks.

It is acknowledged that energy consumption in some of the above buildings (for instance, sheltered housing or out-sourced leisure centres) may not be under the Local Authority's direct management control. Nevertheless, the authority should use the benchmarks as a tool to manage the performance of any contractors who run the buildings.

The following building types are not covered by this guide: housing, schools, police and fire stations, crematoria and plant nurseries. This is because they are either covered by other benchmarking publications, or insufficient data was available from the authorities consulted to enable benchmarks to be compiled.

### Benefits of energy management

- Saving energy saves money, which can be used for other needs
- Saving energy is a demonstration of good overall management within an authority and will help to satisfy the environmental lobby amongst the electorate
- Good energy management often results in lower maintenance costs, reduced plant downtime, improved reliability and longer plant life
- Saving energy results in less environmental pollution from $CO_2$, acid rain and particulates
- Saving energy helps to meet UK Government energy/$CO_2$ reduction targets
- Good energy management practices often result in more comfortable conditions, so that people are neither too hot nor too cold.

### Energy and the environment

The burning of fossil fuels produces gases that are harmful to our environment. These gases include carbon dioxide, sulphur dioxide and oxides of nitrogen. Carbon dioxide and $NO_X$ are greenhouse gases which contribute to climate change. At a local level, a build up of pollutants reduces air quality and can be harmful to human health. The figures in Appendix 1, Table 7 show the mass of carbon dioxide ($CO_2$) released into the atmosphere as a result of consuming a kWh of each fuel.

# 2 Introduction to benchmarks for buildings

## The aims of this guide

- Enable fair comparisons of energy use within the different types of building categories against typical and good practice energy consumption benchmarks. These are based on data collected from a sample of local authority buildings
- Provide a method to prioritise which buildings/sites need attention to improve their energy consumption performance
- Promote the benefits of energy efficiency and provide practical advice on improving performance within buildings.

**What are energy benchmarks?**

Building energy consumption benchmarks provide representative values for common building types against which a building's actual performance can be compared. Comparisons with simple benchmarks of annual energy use per square metre of floor area (kWh/m$^2$/annum, separately for electricity and fossil fuels) allow the standard of energy efficiency to be assessed and priority areas for action to be identified.

The benchmarks presented in this guide are derived by analysing data on each building type obtained from Local Authorities within England and Northern Ireland. The 'typical' benchmark is the median level of performance of all the buildings in the category. 'Good practice' represents the top quartile performance.

**Setting targets for reduced energy consumption**

While it seems natural to set a target in terms of reduction compared with previous energy consumption, it is important to consider whether this approach is fair or realistic. Setting a target for a straightforward overall percentage reduction in energy can be misleading for a number of reasons:

- Percentage improvement targets look back at past performance but give no indication of absolute performance for a particular building nor the potential for future savings
- Past performance may have been particularly poor so that a given absolute improvement might appear good in percentage terms. In the past, blanket percentage improvement targets have often been set for several buildings within a portfolio. Sites that have performed poorly find it easy to achieve the set target, and sites that have performed well find it difficult. This is unfair to sites which have put effort into energy efficiency
- Target percentage savings for the whole portfolio could be achieved when the authority out-sources certain services or mothballs buildings, rather than by improving energy efficiency. Therefore, a percentage improvement on its own is no indication that the portfolio is performing well.

In contrast, benchmarking is a useful tool because:

- Performance can be measured against national standards rather than relative to past performance
- Future energy saving potential can be assessed
- Effort can be targeted on areas of need
- Over-investment can be avoided in buildings already performing well
- Buildings on the same site can be compared
- Similar buildings on different sites can be compared
- Sensible and appropriate targets can be set for each site.

### Using energy benchmarks

The energy consumption data for one year should be divided by the gross internal area to obtain performance indicators for fossil fuel and electricity use. These should then be compared with benchmarks for the relevant building type. The person responsible for energy management should then consider why a particular building meets, exceeds or fails to meet the typical or good practice benchmark in its category. Where intrinsic building characteristics, design features or occupancy patterns cannot explain the performance, the explanation is likely to be in the design, control and/or operation of the building services (lighting, heating and ventilation).

By comparing building or site performance with benchmarks on an annual basis, trends in energy performance over a period of time can be plotted. Changes attract attention for deeper analysis.

### Variety of building types

Since they have various internal functions and operating patterns, different benchmarks are needed for each building type. The building types listed in Table 3 were selected after consultation amongst Local Authorities.

Local Authority buildings, even in the same category, can vary in age and design. There was a surge of public building construction during the Victorian era and whilst some authorities have replaced all their old buildings, others still have grand old properties. Examples of these would include some Town Halls, museums and libraries. The age and design of the remainder of the buildings has also changed due to influences and trends over the last hundred years. Consequently, it should be understood that there is a wide range of energy consumption in some categories.

### Multiple building types on one site

In some cases, a building or site has a combination of functions in different parts of the building – for example a library and swimming pool. If the building is sub-metered, the benchmarks for each building type can be used to make a direct comparison in each area. If a building is not sub-metered for use of fossil fuel or electricity, it may be possible to install sub-metering or temporary metering.

Some buildings may have sub-metering for electricity but not for fossil fuel or vice versa. In these situations, only the sub-metered energy benchmark can be used directly and a composite has to be derived for the energy source with only whole-site metering.

Where there is no sub-metering, the benchmarks can be used proportionally by area. For instance, a combination of two different categories (perhaps 20% day centre and 80% community centre by area) would result in benchmarks pro rata between the two. These can then be compared with the actual fossil fuel and electricity consumption to give an indication of overall site performance.

### Multi-occupancy buildings

Where a building with one set of meters has multiple functions, this guidance can be employed proportionately using the floor area for each use and its associated energy consumption. If the same space is used for multiple functions, the benchmarks can be arrived at by pro-rating on the basis of the percentage duration of each use out of the whole occupied period.

### Buildings with electric or other heating systems

Where a building is heated by a method other than fossil fuel boilers (eg. electric heating, district or community heating system, or boilers combined with CHP), it should not be benchmarked by simply adding the fossil fuel and electricity delivered energy benchmarks. This is because the costs and carbon emissions of the two energy sources are not the same. A procedure to deal with such buildings is being developed, on the basis of the relevant carbon dioxide emissions.

# 3 How to calculate energy performance of buildings

To make use of benchmarks, it is important to adjust raw energy consumption data to the same basis as the benchmarks in order to make a like-for-like comparison. Information necessary for the benchmarking process is:

- Energy consumption data for a year
- Gross internal floor area of the building
- Information on building use
- The degree day data for the location and period of energy consumption to be assessed.

There are four steps to identify the benchmark:

## Step 1: Source energy data and convert to kWh

Annual consumption data should be based on the most accurate and consistent information available. Avoid using estimated readings or consumptions from utility invoices. Use in-house actual meter readings wherever available, or actual meter readings from invoices as a second option.

If there are no actual readings for the period being evaluated, try to find two actual readings approximately one year apart from previous records. Start in-house meter readings for future checks.

For fuels measured on delivery rather than usage, try to obtain the delivery quantities which return the store to the same level. This may necessitate some judgement, or apportionment over a different time period for twelve months.

Electricity is displayed on the meter in kWh but readings for other types of fuel must be converted to kWh so that a common energy unit is used, based on conversion factors from Table 1.

DEFRA meter reading guidance is available at: **http://www.defra.gov.uk/enviroment/cd/pdf/ccall.pdf**

| Fuel | Measured units | To get to kWh, multiply by |
|---|---|---|
| Electricity | kWh | 1.0 |
| Natural Gas | $m^3$ | 10.7 |
| | kWh | 1.0 |
| | $100ft^3$ | 30.3 |
| Gas oil (35 sec) | litres | 10.6 |
| Light fuel oil (290 sec) | litres | 11.2 |
| Medium fuel oil (950 sec) | litres | 11.3 |
| Heavy fuel oil (3500 sec) | litres | 11.4 |
| LPG/propane | kg | 13.8 |
| Coal – bituminous | kg | 5.6 |
| Coke | kg | 8.2 |
| Semi-anthracite | kg | 8.2 |
| Anthracite | kg | 9.2 |

**Table 1. Fuel conversion factors**

Note that the calorific value (CV) of any of the fuels can vary widely in the case of the various types of solid fuel. If you are burning solid fuel to provide your heating and/or hot water requirements, it is recommended that you contact your supplier to establish the type and if possible, its CV. If it is not possible to establish this value accurately and if the fuel type has not changed, it is recommended that a similar value from this table is used for year on year benchmark calculations.

## Step 2: Adjust the space-heating energy to account for the weather

A building uses more energy during severe weather. In order that a reasonable comparison can be made with the data from different years, a correction factor is applied. There is an outside 'base' temperature (taken to be 15.5°C for most buildings), above which heating is deemed unnecessary because of internal heat gains from people, equipment, lights and solar gain.

The space heating requirement is dependent on the number of 'degree days' relative to the base temperature.

*Degree days are a measure of how cold it is and the duration of the coldness. For heating degree days, the procedure is based on the difference between the daily outside air temperature and some notional 'base' (the outside temperature at which no heating would be required). For each region, daily results are added to a running total, either over the course of a calendar month, or a year.*

*As an example, if the average outside air temperature during one week was 12.5°C, this would represent a heating requirement for the building based on (15.5 - 12.5) x 7 = 21 degree days.*

*Degree day information is available from:*
**http://vesma.com/ddd/index.htm**

In order to calculate the weather correction factor, the total degree days for a standard year are divided by the degree days for the year in which the energy data is to be considered.

The benchmarks have been adjusted (normalised) for 2,462 degree days.

$$\text{Weather correction factor} = \frac{\text{Standard degree days (2462)}}{\text{Degree days for energy data year}}$$

Variation in degree days only affects the space-heating component of the fossil fuel consumption and not the water-heating component. It is for this reason that the two components must be treated separately. In buildings where hot water is used mainly for hand-washing, the water heating component is relatively small and it would not make a significant difference if it is included in the weather correction. In buildings where there is substantial swimming pool heating, bathing, showering, laundry or food preparation, the proportion of water heating needs to be estimated and removed from the part of the fossil fuel data which is weather-corrected. It is then added back into the fossil fuel total after the space heating part has been weather corrected.

It is also possible to normalise the energy consumption for other factors (such as weather exposure or operating hours) but in order to simplify this example, they are not considered here.

# Step 3: Determine floor area

Floor area can be defined in different ways:

- **Gross Internal Area (GIA)** – total building measured inside external walls
- **Treated Floor Area (TFA)** – gross area less plant room and other areas not directly heated (eg stores, covered car parking and roof spaces)
- **Net Lettable Area (NLA or ALA)** – GIA less the common areas and ancillary spaces; agent’s lettable area.

The floor area used to determine the Local Authority building benchmarks is the **Gross Internal Area (GIA).**

### Estimating floor area

Gross internal area (GIA) is used as the denominator for energy indices in this guide because it is the most readily available area which is not subject to interpretation. Wherever possible, this area should be measured from scale plans or direct from the building.

In those cases where some other area is all that is available, (for instance where the property is leased and only the Agent’s Net Lettable Area is quoted), a conversion will be necessary. Area conversion factors vary from building to building depending on geometry, spatial efficiency, and areas devoted to plant rooms, unheated storage, etc. Rules of thumb based on case study data for commercial office buildings are shown in Table 2. Newer buildings often aim for higher ratios, for example by using more efficient use of circulation space, external escape stairs, and some roof-mounted plant. In this case, Table 2 may not apply.

These estimated values can be used for this indicator. If precise comparisons are required, measurement from scale plans or direct from the building will be necessary.

If performance against benchmarks is being compared year on year, it is important for the area used in the calculation to be consistent. If more accurate area data comes to light between one year and the next use it but make an appropriate adjustment when undertaking comparisons year on year.

For depots, the area is that of the buildings, not the open yard. For car parks, it is the total car parking and circulation area.

| Type of office building | Treated % of Gross | Net Lettable % of Gross |
|---|---|---|
| 1 Naturally ventilated cellular | 95% | 76% |
| 2 Naturally ventilated open plan | 95% | 76% |
| 3 Air-conditioned, standard | 90% | 72% |
| 4 Air-conditioned, prestige | 85% | 68% |

**Table 2.** Floor area conversion factors, published in ECG019 for offices

# Step 4 Calculate performance indicators

Performance indicators for fossil fuel and electricity can now be calculated.

$$\text{Fossil-fuel performance indicator} = \frac{\text{Weather corrected annual fossil-fuel consumption for heating} + \text{uncorrected annual fossil-fuel consumption for hot water}}{\text{GIA floor area}} \quad (\text{kWh/m}^2\text{/annum})$$

$$\text{Electricity performance indicator} = \frac{\text{Annual electricity consumption}}{\text{GIA floor area}} \quad (\text{kWh/m}^2\text{/annum})$$

These performance indicators can then be compared with the benchmarks for the relevant building category listed in Table 4.

# 4 Building categories of local authority portfolios

### Diverse types of buildings

Local Authorities manage a wide variety of building types that serve the community in different ways. Some of the buildings date from the Victorian era when many public buildings were constructed and of these, some continue to serve in their original capacity such as Town Halls and libraries. Others have seen their building usage change over time, such as schools or old pumping stations becoming museums.

Over the last hundred years, the portfolios have grown and changed in many ways and the result today is a diverse range of buildings in terms of age, design and usage. From the feedback from Local Authorities who contributed data to this guide, the following categories of building have been identified as those in typical portfolios with significant energy consumption under their managerial control.

| Category | Description |
|---|---|
| Town Hall | • Traditionally the centre of Local Government, often in grand Victorian buildings<br>• The building where the Town Council hold meetings and local government officials have chambers<br>• Provides reception rooms for community functions and visiting dignitaries<br>• A venue for events and exhibitions organised by the local community |
| Civic Offices | • Office accommodation in addition to Town Hall<br>• Could be part of a civic complex (connected to library, shops and theatre) |
| Leisure centres | • Sport centres, swimming pools and leisure centres |
| Libraries | • Includes traditional Victorian libraries and their modern counterparts<br>• Opening hours may vary from 6 days/week 9am – 5pm to 4 days/week 9am-2pm<br>• Often have high ceilings to maximise the use of daylight |
| Museums | • Building age may vary from unique old building adapted to suit purpose (old school, pumping station, tram depot), to modern purpose built museums<br>• Often have high ceilings to accommodate a variety of exhibit<br>• Occupancy hours may vary, from 30 – 48 hours/week |
| Residential care homes | • Accommodation and care for groups with special needs, often either housebound elderly residents, young people or adults in care<br>• Heating required 24 hours/day<br>• Often have dedicated nursing or other care staff in residence |
| Sheltered housing | • Residents are independent and may wish to leave during the day<br>• Similar building performance to housing, but with elevated temperatures for the elderly |
| Housing units for homeless people | • Basic accommodation units<br>• Residents may be required to (or wish to) leave the premises during the day |
| Community centres | • Used for local activities organised by councils or local groups<br>• May have basic sports facilities as part of a Youth Centre<br>• Occupation hours may vary considerably – from occasional evening use (20 hours/week) to 7-days/week active vibrant community centre (80 hours/week) |
| Day centres | • Buildings and parts of buildings occupied during the day by groups with special needs<br>• Often contain catering, laundry and bathing facilities |
| Depots | • Large storage areas for Local Authority equipment (bins, signs, seasonal decorations, sand, salt, building supplies etc)<br>• May have small associated office |
| Car parks | • Open car parks may have basic lighting facility<br>• Multi storey car parks have significant lighting requirement |

**Table 3.** Building Categories within Local Authority Portfolios included in this guide. (Note that school buildings are covered in other Carbon Trust energy consumption guides)

When comparing Local Authorities, it is important to acknowledge that the mix of buildings in their portfolios may differ considerably. As well as dealing with individual buildings, this guide provides a method for comparing the performance of the whole portfolio with benchmarks.

# 5 Variations in energy consumption

### Types of building covered by benchmarks

Table 3 identifies the buildings for which there are benchmarks. Some may be referred to by different names dependent upon regional and political influence.

Housing units for homeless people have recently become more prevalent in parts of the country where there has not been a requirement previously. These are often conventional domestic properties which have been transferred from council housing departments. Care homes for young people are also likely to have previously been domestic property.

In some cases, other sources of better tailored Carbon Trust benchmarks are available, for instance for office buildings or sports centres other than the quoted types. This tailoring can accommodate different activities, operating hours and other energy uses within the building. It is acceptable to use these alternative benchmarks if the source is referenced.

### Key influences on energy consumption

Factors which influence energy consumption in all building types include:

- Building age (older buildings tend to be thermally heavy weight, have higher ceilings and have poor insulation)
- Air tightness varies between all buildings
- Micro-climate and exposure
- Design features (whether the space is used effectively; type of lighting, heating and ventilation system and particularly whether and for how long air conditioning is used)
- Hours of actual occupation/use
- Quality of the building operation regime
- Effectiveness of the controls installed and whether they are clearly labelled and well positioned
- Correct usage of building controls
- Motivation of staff to operate building energy efficiently.

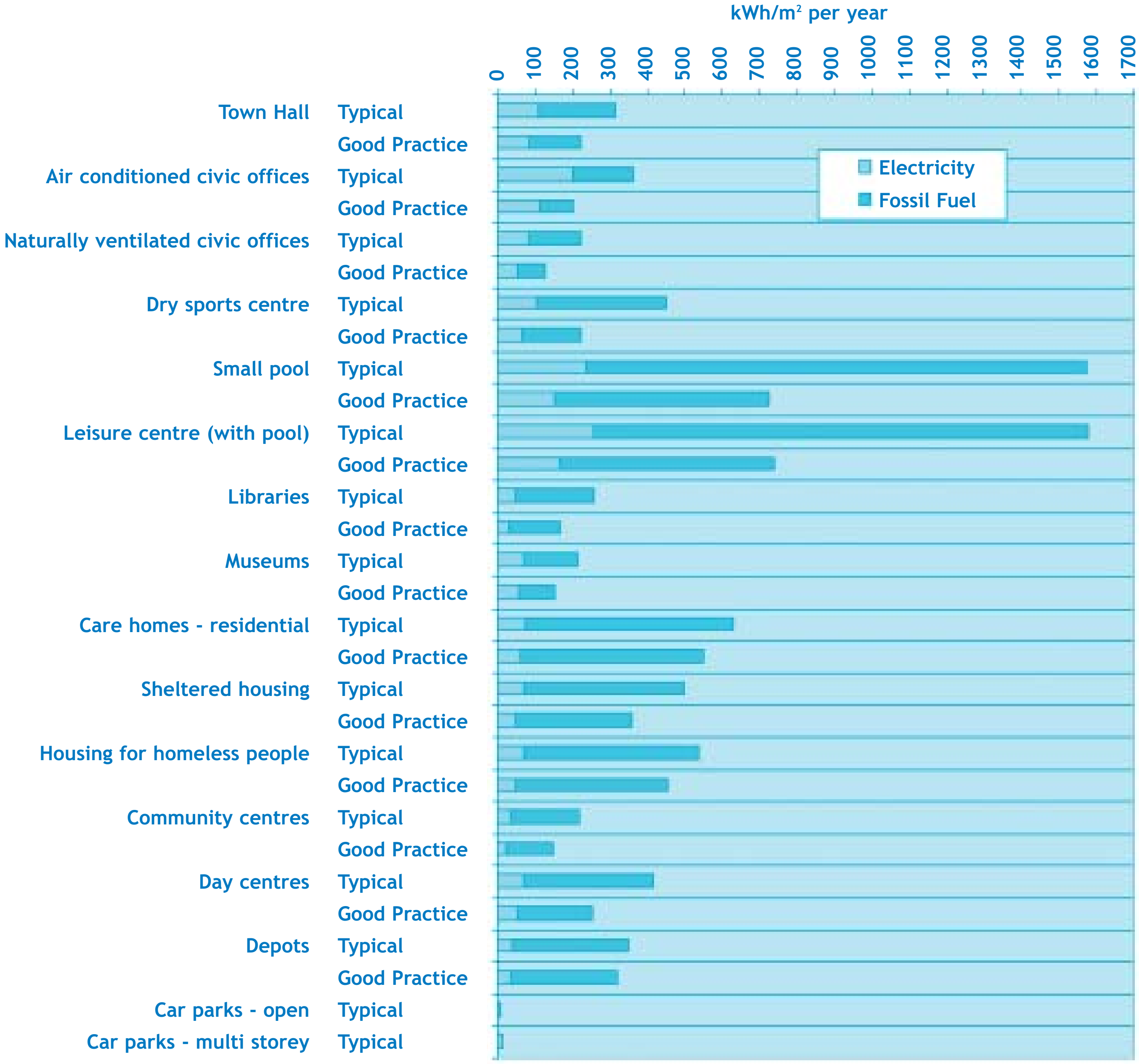
Depending on how each of the above factors can be related to the building in question, the Energy or Property Manager should be able to justify why the building is closer to the typical or good practice levels of energy consumption. In some circumstances, there are other reasons unique to the property which can explain particular energy consumption characteristics (for example, a water feature, or use as an exhibition venue). Where there is no overriding apparent reason to explain higher levels of energy consumption, the benchmarking exercise identifies sites that need to be investigated and targeted as potential areas for achieving energy and cost savings. Knowing performance against both typical and good practice also helps Local Authorities to set realistic improvement targets. There is no point in expecting a large improvement from a building which already meets the good practice benchmark.

### Possible reasons why buildings have high energy consumption

Where higher levels of energy consumption cannot be explained by one of the above factors, the main areas of investigation should address the following:

- How appropriate is the control system for heating, ventilation and/or air conditioning?
- Does the controls system match occupancy patterns?
- Are appropriate levels of internal comfort conditions being maintained - is the building too warm during heating, too cool when air conditioned, or is the air change rate too high?
- Is the building manager accountable for costs or energy use?
- Can the lighting be turned off (or partially off) during low occupancy periods or on bright days?
- Is equipment use matched to occupancy, e.g. are personal computers turned off when people are away from desks?
- Are there maintenance issues (blocked filters, dirty light fittings, broken controls, draughty doors and windows)?
- Is there a problem with the data - are the meters being read correctly, or is there another building benefiting from the fuel/electricity supply?

# 6 Building benchmarks




**Typical**

The median consumption performance of all the data collected from a range of Local Authorities

**Good Practice**

The upper quartile performance of the monitored data collected from a range of Local Authorities

Energy consumption benchmarks are quoted in kWh/m² in Table 4

| Category | Electricity kWh/m$^2$ | Fossil Fuel kWh/m$^2$ | |
|---|---|---|---|
| Town Hall | 111 | 205 | Typical |
| Town Hall | 84 | 138 | Good practice |
| Air conditioned civic offices * | 203 | 160 | Typical |
| Air conditioned civic offices * | 115 | 87 | Good practice |
| Naturally ventilated civic offices * | 81 | 143 | Typical |
| Naturally ventilated civic offices * | 51 | 75 | Good practice |
| Dry sports centre † | 105 | 343 | Typical |
| Dry sports centre † | 64 | 158 | Good practice |
| Small pool † | 237 | 1336 | Typical |
| Small pool † | 152 | 573 | Good practice |
| Leisure centre (with pool) † | 258 | 1321 | Typical |
| Leisure centre (with pool) † | 164 | 573 | Good practice |
| Libraries | 46 | 210 | Typical |
| Libraries | 32 | 133 | Good practice |
| Museums | 70 | 142 | Typical |
| Museums | 57 | 96 | Good practice |
| Care homes - residential | 75 | 555 | Typical |
| Care homes - residential | 59 | 492 | Good practice |
| Sheltered housing | 68 | 432 | Typical |
| Sheltered housing | 46 | 314 | Good practice |
| Housing units for homeless people | 71 | 467 | Typical |
| Housing units for homeless people | 48 | 408 | Good practice |
| Community centres | 33 | 187 | Typical |
| Community centres | 22 | 125 | Good practice |
| Day centres | 68 | 349 | Typical |
| Day centres | 51 | 203 | Good practice |
| Depots | 39 | 311 | Typical |
| Depots | 37 | 283 | Good practice |
| Car parks – open | 1 | | Typical |
| Car parks – multi storey | 15 § | | Typical |

**Table 4** Typical and good practice energy performance benchmarks for different building types, related to Gross Internal Area

The typical benchmark is the median level of performance. Good practice represents the top quartile performance of all the buildings surveyed. Where there is electric heating, do not simply add the above fossil fuel and electricity delivered energy benchmarks together as this would not take into account the different operating costs and carbon dioxide emissions caused by electricity generation.

* see also ECG019 and Carbon Trust website

† see also ECG078

§ range 10 - 100

# Appendix 1

## Relating energy use to carbon emissions

Each kWh of energy delivered to a building incurs atmospheric emissions of the major greenhouse gas $CO_2$ from the extraction, processing, delivery of each fuel and its consumption on site.

For the purpose of comparability with other statistics, $CO_2$ emissions in this Guide are quoted as kg of $CO_2$ per kWh of delivered fuel (kg $CO_2$/kWh).

Quoted conversion factors vary according to the assumptions made.  Table 7 shows the conversions used here in carbon dioxide per kWh of delivered fuel. They are taken from the DEFRA Guidelines at ***www.defra.gov.uk/environment/envrp/gas/05.htm***

The conversion factor for electricity varies with the primary fuel mix used to generate it. This table may differ slightly from those in other sources, due to different assumptions about fuel use and electricity generation mix for different sectors and the time the conversions were derived.

| Fuel | $kgCO_2$/kWh |
|---|---|
| Natural Gas | 0.19 |
| Fuel Oil (35s) | 0.25 |
| Coal | 0.30* |
| Electricity average | 0.43 |
| LPG | 0.21 |

**Table 7.** $CO_2$ conversion factors to be used for year on year comparisons.

* It should be noted that values for coal can vary, depending on the type of coal used.  Users should confirm with their suppliers.

# Appendix 2

## Example calculation for single building

Town Hall with gas heating

A Town Hall building in the Midlands with a gas-fired heating system. Separately metered from other buildings. Hot water usage for washing is minimal.

Gross floor area = 6,232 $m^2$

Gas consumption for the year March 2001 – April 2002 = 800,000 kWh per year

Electricity consumption is 720,000 kWh per year

### Step 1

The energy consumptions are already in units of kWh per year. It is understood that the information is based on actual meter readings, not estimated data.

### Step 2

**Degree day adjustment**

There were 2,030 degree days in the Midland region for the 12 month period April 2001 – March 2002 (based on data from http://vesma.com/ddd/history.htm).

The energy used for heating needs to be adjusted so it can be compared to data from the standard year (2,462 degree days). Assume that all the fossil fuel is used for space heating.

The adjusted gas consumption is

$$\frac{\text{standard degree days (2,462) x 800,000 kWh}}{\text{degree days for energy data year (2,030)}} = \text{970,246 kWh}$$

### Step 3

**Floor areas**

The gross internal floor area is 6,232 $m^2$

### Step 4

**Calculating performance indicators (PI)**

$$\text{Fossil-fuel PI} = \frac{\text{Weather corrected annual fossil-fuel consumption}}{\text{GIA floor area}} = \frac{970246}{6232} = 156\ \text{kWh/m}^2\text{/annum}$$

$$\text{Electricity PI} = \frac{\text{Annual electricity consumption}}{\text{GIA floor area}} = \frac{720000}{6232} = 116\ \text{kWh/m}^2\text{/annum}$$

In this example, the fossil fuel PI of 156 kWh/$m^2$ is between the good practice and typical benchmarks of 138 and 205 kWh/$m^2$ per year.

The electricity PI of 116 kWh/$m^2$ is above the typical benchmark of 111 kWh/$m^2$ and indicates there may be opportunity for savings.

# Appendix 3

## Benchmarking individual buildings and a portfolio

There may be several buildings in a Local Authority's portfolio which need to be benchmarked. In order to prioritise action, a spreadsheet with one line for each building can be set up to ensure that the analysis is consistent and performance of all buildings can be compared. The same spreadsheet can also be used to compile a portfolio benchmark.

In this document, such a spreadsheet is presented as several separate tables in order to fit the printed page. Only columns relevant to the individual building analysis are shown in Table 8, while those relevant to the portfolio benchmark are shown in Table 9. In practice, all columns would be in the same spreadsheet.

## Individual buildings

In the example in Table 8, the performance indicators for electricity and fossil fuel for each building are calculated and compared with the typical benchmark in terms of 'percentage of typical'. Buildings with consumption more than 100% of typical should be examined carefully to establish why. Priority should be given to buildings with consumptions much more than 100% of typical; it will be for the Authority to determine a suitable threshold such as 120%. The comments column can be used to indicate action. It might be that a building is over 100% of typical for one energy source, but not the other – this indicates which energy source needs the most attention.

The table also lists good practice benchmarks and it will be useful to motivate building managers and occupants by showing which buildings come below this threshold.

## Portfolio benchmarking

In order to benchmark a portfolio of buildings as a whole, it is necessary to combine the benchmarks for a variety of building types and areas.

This can be achieved by developing a spreadsheet (Table 9) which considers what the fossil fuel and electricity consumption of each building would have been, had it met the typical benchmarks. This is the 'typical consumption'. These consumptions of electricity and fossil fuel can then be summed for all the buildings in the portfolio, and the resulting 'aggregated typical consumptions' compared with the actual total consumptions of each of those energy sources. The relationship will show whether the portfolio as a whole, normalised for building type and area, performs better or worse than typical.

Such a portfolio benchmark is fairer than one that looks at the straightforward overall energy consumption per square metre, as it compensates for buildings that have intrinsically higher energy consumption to achieve the right conditions, and their different areas. It also accommodates changes to the portfolio between assessments, as the new aggregated typical consumption matches the new mix of building types and areas.

It should be appreciated that, since the typical benchmarks represent the median performance for buildings of each type, it is quite likely that individual buildings and the whole portfolio may be worse than typical. By the very nature of the way the benchmarks have been compiled, up to half the portfolios considered will be worse than typical since this represents the median value of the data collected.

Thus, although individual buildings above 100% of typical should demand attention, the measure of performance for a whole portfolio should be to review how performance, relative to typical, changes year on year. A worsening performance (increasing % of typical) indicates that either:

- Management of the portfolio is deteriorating
- New buildings added to the portfolio since the previous assessment were significantly worse than the average for that Local Authority (this can of course be verified by checking the individual buildings' benchmarks)

In either case, the Local Authority should take action by tightening up management of the buildings, or being more proactive in selecting good quality buildings to join the portfolio. To avoid the latter situation, the Local Authority should specify in the brief for new building acquisitions that performance should be capable of meeting good practice benchmarks for the building type.

| A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|
| Table 8a | | Electricity | | | | | |
| Building | Gross Internal Area sqm | Actual metered kWh | Actual PI kWh/sqm | Typical benchmark kWh/sqm‡ | Actual % of typical † | Good practice benchmark kWh/sqm‡ | Comments |
| Town Hall | 7100 | 912000 | 128 | 111 | 116 | 84 | Electricity consumption high |
| Civic office air con | 4300 | 890000 | 207 | 215 | 96 | 122 | Electricity consumption close to typical but room for improvement |
| Library | 1100 | 43200 | 39 | 46 | 85 | 32 | Looks reasonable |
| Museum | 1200 | 63200 | 53 | 70 | 75 | 57 | Meets good practice benchmarks - very good! |
| Leisure centre | 2500 | 615000 | 246 | 258 | 95 | 164 | Comparison with typical OK, but absolute consumption high - seek improvements |
| Community centre | 600 | 24000 | 40 | 33 | 121 | 22 | Electricity 121% of typical but absolute consumption not high, so needs attention but not high priority. |
| Replicate for other buildings... | | | | | | | |

| A | B | I | J | K | L | M | N | O | P | Q |
|---|---|---|---|---|---|---|---|---|---|---|
| Table 8b | | Fossil fuel | | | | | | | | |
| Building | Gross Internal Area sqm | Actual metered kWh | Actual degree days for metered period | % heating which is weather dependent | Weather corrected to 2462 degree days kWh ◊ | Actual (weather corrected)PI kWh/sqm | Typical benchmark kWh/sqm‡ | Actual (weather corrected % of typical † | Good practice benchmark kWh/sqm‡ | Comments |
| Town Hall | 7100 | 1190000 | 2240 | 85 | 1290247 | 182 | 205 | 89 | 138 | Heating reasonable |
| Civic office air con | 4300 | 998088 | 2240 | 95 | 1092060 | 254 | 169 | 150 | 92 | Poor control of heating? |
| Library | 1100 | 163200 | 2240 | 97 | 178889 | 163 | 210 | 77 | 133 | Looks reasonable |
| Museum | 1200 | 103600 | 2240 | 95 | 113354 | 94 | 142 | 67 | 96 | Meets good practice benchmarks - very good! |
| Leisure centre | 2500 | 2802500 | 2240 | 50 | 2941374 | 1177 | 1321 | 89 | 573 | Comparison with typical OK, but absolute consumption high - seek improvements |
| Community centre | 600 | 66400 | 2240 | 95 | 72652 | 121 | 187 | 65 | 125 | Heating good practice |
| Replicate for other buildings... | | | | | | | | | | |

**Table 8.** Analysis of each building in portfolio to compare actual performance with benchmark and indicate where remedial action is required

† > 100% indicates buildings which need priority attention, although those below 100% could also be improved

‡ typical and good practice benchmarks from Table 4

◊ note that only the weather-dependent component is adjusted pro rata to degree days. Part of actual metered fossil fuel for non weather-dependent loads, (e.g. for catering, bathing/laundry hot water or pool heating) is not adjusted

## Example calculation for individual buildings

In Tables 8a and 8b, each row deals with one building. Although a limited number of buildings are shown, in an actual example, all the buildings in the portfolio would be tabulated. Groups of columns deal with basic data (A,B), electricity (C to G), fossil fuel (I to P) and comments (H&Q). Columns coloured green (A,B,C,I,J,K) are data entered on each building. Appropriate typical (yellow columns) and good practice (orange) benchmarks from Table 4 for each building type are entered in each row. In this description, example figures taken from the table are shown in ***bold***.

In Table 8a for electricity, the actual performance indicator for the building is calculated in column D from C/B ***(For example Town Hall: 912000/7100 = 128)***. This is then compared with the typical benchmark to give percentage of typical in column F (D/E x100) ***(For Town Hall: 128/111x100 = 116% of typical)***. If the actual performance is well below typical, it can be compared with good practice in column G ***(84)***. An appropriate comment can be entered in column H as a prompt for action.

For fossil fuel in Table 8b, the metered performance (I) has to be adjusted to take account of degree days in the period that the consumption took place (J), so that the performance can be compared with benchmarks normalised for 2462 degree days.

This adjustment should only be applied to the part of the consumption which is weather dependent (K), which may have to be estimated if there is no appropriate sub metering. Reductions from 100% in this column are made for hand washing, catering or laundry needs, or for heating swimming pools ***(For Town Hall, say 15% of heat energy is used for catering and hand washing, which is not weather-dependent. Hence the figure entered in K is 100 - 15 = 85% of heating is weather-dependent)***. Sometimes the adjustment can be estimated from the water heating energy indicated in other benchmarking publications, such as ECG019 for offices or ECG078 for sports centres.

The weather corrected consumption (L) is calculated from IxK%x2462/J (weather dependent part) + Ix(100-K%) (non weather dependent part) ***(For Town Hall assuming 85% heating is weather dependent:1190000 x 0.85x2462/2240 + 1190000x0.15 = 1290247)***.

The weather corrected performance indicator (M) is given by L/B ***(For Town Hall: 1290247/7100 = 182),*** which can then be compared with the typical benchmark to give percentage of typical in column O (M/N x100) ***(For Town Hall: 182/205x100 = 89% of typical)***. As with electricity, comparisons can also be made with good practice benchmarks in column P ***(138)***, and comments made in column Q.

## Example calculation of portfolio benchmarks

Tables 9a and 9b show an example of how to calculate portfolio benchmarks to assess overall performance of a local authority's buildings. The tables should use the same data on individual buildings entered in Table 8 for consistency and to avoid repetition of data input. For the purposes of explanation in this publication, Table 9 concentrates only on the columns and information necessary to calculate the portfolio benchmark and has been split into two to deal with electricity and fossil fuel separately. Users may wish to combine the functions of Tables 8 and 9 in one spreadsheet.

Similarly to Table 8, groups of columns deal with basic data (A,B), electricity (C to E) and fossil fuel (F to K) consumption. Columns coloured green (A,B,C,F,G,H) are data entered on each building. Appropriate typical (yellow columns) benchmarks from Table 4 for each building type are entered in each row.

**Portfolio performance indicator**

The electricity 'typical consumption' for each building is calculated in column E from BxD ***(For example for Town Hall: 7100x111 = 788100)***. The total actual consumption for all buildings is then compared with the 'aggregated typical consumption' to give the portfolio 'percentage of typical' at the foot of column E (total C/total E x100) ***(Example in Table 9: 2547400/2512000x100 = 101% of typical)***.

For fossil fuel, the metered performance for each building (F) has to be adjusted to take account of degree days in the period that the consumption took place (G), so that the performance can be compared with benchmarks normalised for 2462 degree days. This adjustment should be undertaken in the way described for Table 8. The weather corrected consumption (I) is calculated from FxH%x2462/G (weather dependent part) + Fx(100-H%) (non weather dependent part) ***(For Town Hall:1190000x0.85x2462/2240 + 1190000x0.15 = 1290247)***.

The fossil fuel 'typical consumption' for each building is calculated in column K from BxJ ***(For Town Hall: 7100x205 = 1455500)***. The total weather corrected consumption for all buildings in the portfolio is then compared with the aggregated typical fossil fuel consumption to give the portfolio 'percentage of typical' at the foot of column K (total I/total K x100) ***(Example in Table 9: 5688575/5998300x100 = 95% of typical)***.

This gives percentage of typical figures for electricity and fossil fuel delivered energy consumption, across the whole portfolio. It is suggested that these figures are tracked year on year to check whether performance is improving or deteriorating.

The above is a step by step illustration of the methodology involved in calculating portfolio benchmarks. Many users will wish to combine and expand Tables 8 and 9, as already mentioned, to include more information or perhaps to calculate $CO_2$ emissions using appropriate $CO_2$ conversion factors for each of the energy sources from Table 7.

| A | B | C | D | E |
|---|---|---|---|---|
| Table 9a | | Electricity | | |
| Building | Gross Internal Area sqm | Actual Metered kWh | Typical Benchmark kWh/sqm ‡ | Total Typical kWh |
| Town Hall | 7100 | 912000 | 111 | 788100 |
| Civic office air con | 4300 | 890000 | 215 | 924500 |
| Library | 1100 | 43200 | 46 | 50600 |
| Museum | 1200 | 63200 | 70 | 84000 |
| Leisure centre | 2500 | 615000 | 258 | 645000 |
| Community centre | 600 | 24000 | 33 | 19800 |
| Replicate for other buildings... | | | | |
| Totals | 16800 | 2547400 | | 2512000* |
| Portfolio Actual:Typical % # | | | | **101** |

| A | B | F | G | H | I | J | K |
|---|---|---|---|---|---|---|---|
| Table 9b | | Fossil fuel | | | | | |
| Building | Gross Internal Area sqm | Actual Metered kWh | Actual Degree Days for Metered period | % Heating Which is Weather Dependent | Weather Corrected To 2462 Degree Days kWh ◇ | Typical Benchmark kWh/sqm ‡ | Total Typical kWh |
| Town Hall | 7100 | 1190000 | 2240 | 85 | 1290247 | 205 | 1455500 |
| Civic office air con | 4300 | 998088 | 2240 | 95 | 1092060 | 169 | 726700 |
| Library | 1100 | 163200 | 2240 | 97 | 178889 | 210 | 231000 |
| Museum | 1200 | 103600 | 2240 | 95 | 113354 | 142 | 170400 |
| Leisure centre | 2500 | 2802500 | 2240 | 50 | 2941374 | 1321 | 3302500 |
| Community centre | 600 | 66400 | 2240 | 95 | 72652 | 187 | 112200 |
| Replicate for other buildings... | | | | | | | |
| Totals | 16800 | 5323788 | | | 5688575 | | 5998300* |
| Portfolio Actual:Typical % # | | | | | | | 95 |

**Table 9.** Calculation of portfolio benchmarks

# Portfolio benchmark - gives comparison with area compensated typical benchmarks. > 100% indicates authorities which do not meet typical benchmark, but of course some will be above as well as some below typical, since it was based on the median consumption for each building type. If a local authority is above 100% this may just mean they started with a poor portfolio of buildings. The comparator should be year on year change in this performance indicator - increase means worsening energy management of the stock they have

‡ Typical benchmarks from Table 4

◇ Note that only the weather-dependent component is adjusted pro rata to degree days. Part of actual metered fossil fuel for non weather-dependent loads, eg for catering, bathing/laundry hot water or pool heating, is not adjusted

* Aggregated typical consumption

# Appendix 4

## Local authority portfolio annual energy use and spend

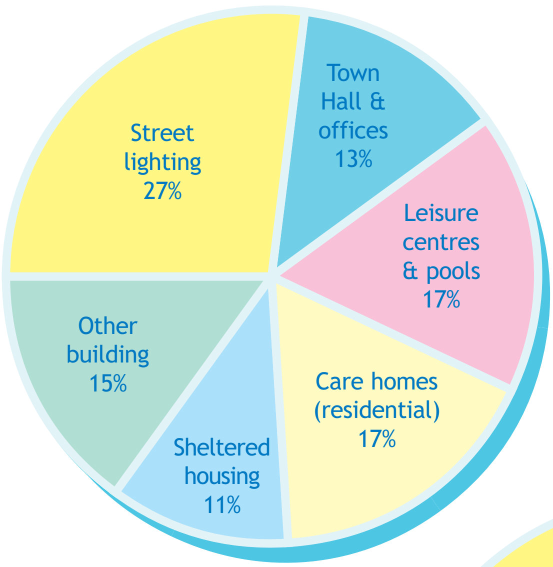
### Average energy unit costs

Fuel costs can vary widely with size and pattern of demand and with expertise of procurement departments. Local Authorities have traditionally been able to achieve competitive energy rates with their size of portfolio and by collaborating with other authorities.

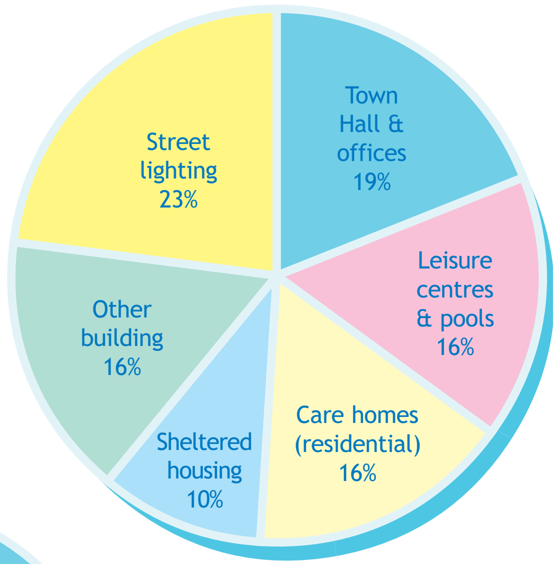
Each Authority should have its own average unit cost data available. For the purpose of this report, the basic unit costs in Table 10 have been used to demonstrate the financial breakdown of the categories.

| **Assumed cost per kWh delivered**<br>Includes: standing charges & climate change levy<br>Excludes: VAT | |
|---|---|
| Gas | 1.5p |
| Electricity – buildings | 6p |
| Electricity – unmetered supplies | 2p |

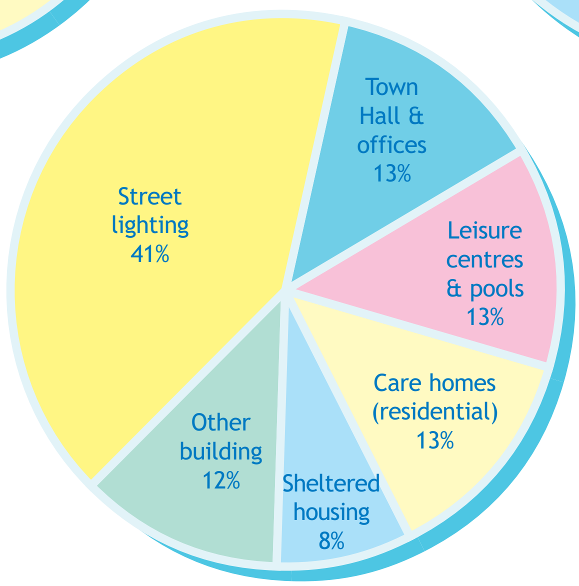
**Table 10.** Unit fuel costs




**GWh**




**£**




**Carbon Dioxide**

Note that street lighting is not addressed in this publication. There is a proposal to develop a methodology for benchmarking street lighting, in consultation with Local Authorities and The Institution of Lighting Engineers.

# Appendix 5

## Energy saving measures

### General

All options involving capital investment should be compared on the basis of treasury recommendations, that is, life cycle costing at the prevailing discount rate (currently 3.5%).
For more information, visit:
***http://greenbook.treasury.gov.uk/index.htm***
(click on 'Economic Data and Tools' then click on 'PDF file of The Green Book: Appraisal and Evaluation in Central Government'). The advice is not specific to energy efficiency but covers related issues that impact on energy and its use.

### Local Authority buildings

It is recommended that the following general measures be considered for all buildings within Local Authority portfolios as a starting point of comprehensive energy management:

- Ensure heating, ventilation and air conditioning operation matches occupancy times
- Ensure there are labels and notices within the building to inform staff about the correct operation of all lighting and heating/air conditioning systems
- Encourage the staff to take monthly electricity, gas and water readings and to use this for in-house monitoring and targeting. It would also be useful as part of a charging system if the building is sub-let
- Check all the control settings each month (particularly at summer/winter time changes). Heating and ventilation controls and time switches for outside lighting should be regularly checked to ensure the on/off times are appropriate and the controller clock is correct. Weekend operation should be prevented unless required and the installation of 7-day time switches specified if necessary. Try to avoid running the whole system when only one or two people work out of normal hours. If it happens regularly, arrange for spot heating in their area only
- Lighting in areas not continually occupied (eg sports halls, meeting rooms) should be controlled by movement sensors
- All light switches should be labelled
- In buildings where there is a hot water requirement outside the heating season, hot water should be generated without the need for running the main heating boilers. This can be achieved by instantaneous gas fired water heaters, small dedicated gas boilers or electric water heating (for small loads)
- All replacement gas boilers should be carefully sized and specified as condensing low $NO_X$ boilers
- All new or refurbishment lighting projects should ensure that high frequency lighting is used in open plan office areas with individual switching and additional control by movement sensors
- Taps should be spray taps (in soft water areas) to reduce water flow and shower units should be push-button operated
- Urinals should be specified as 'low water' or 'waterless units' and toilets should have the urinal flushing, lighting and ventilation controlled by occupancy sensors
- Doors should have automatic closers
- Fit time switches to fan convector heaters
- Consider installing combined heat and power where established appraisal techniques demonstrate that it is viable
- Where heat density in the area is high consider linking to or establishing a community heating network (see heat density maps at ***http://www.est.org.uk/communityenergy/heatmaps.cfm)***

### Leisure centres

Energy management within leisure centres and swimming pools is a specialist area and is addressed in ECG078: 'Energy use in sports and recreation buildings'. In addition to the general measures listed on page 22, it is recommended that the following be checked in all leisure centres to ensure energy is being used efficiently:

- Use pool covers to reduce heat loss and evaporation at night
- Regularly monitor of water and air temperatures in pool areas
- Ensure occupancy time matches heating, ventilation and lighting usage
- Ensure air change rate is controlled by humidity sensors – once the required humidity level is achieved, the air change rate can be reduced using variable speed ventilation fans.

### Residential care homes

These can use a significant portion of the annual fossil fuel spend for a Local Authority as the buildings are often heated continually. In addition to the general measures listed on Page 22:

- Ensure the building fabric is thermally effective (loft insulation, draft proofing, double glazed windows, cavity wall insulation)
- Ensure heating system controls are adjusted (particularly the compensated boiler flow temperatures and the application and correct adjustment of thermostatic radiator valves), in order to acheive energy savings following improvements to building fabric.

# Appendix 6

## Acknowledgments

This guide has been prepared with the help and co-operation of the following who have provided information on energy consumption within their portfolios, advice on their specialist areas and the images throughout this guide:

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Northamptonshire
County Council
County Hall
LETTERBOX AT
GEORGE ROW
ENTRANCE

# Appendix 7

## References

***Web address: www.thecarbontrust.co.uk/energy***

The following Carbon Trust publications are available through the above website together with more information on measures to improve energy efficiency:

ECG019: Energy use in offices

ECG078: Energy use in sports and recreation buildings

GPG311: Detecting energy waste (for the government estate but applicable to many sectors)

GPG312: Invest to save? (for the government estate but applicable to many sectors)

GPG376: A strategic approach to energy and environmental management

Tel 0800 58 57 94

www.thecarbontrust.co.uk/energy

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